

GROSS ALPHA AND BETA ACTIVITY ANALYSIS USING LIQUID SCINTILLATION TECHNIQUE IN MINERAL WATERS IN THE NORTH OF IRAN

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A project to characterize the Gross-alpha and beta activities in order to checking compliance to derived limit values in mineral spring waters in the vicinity of Rasht city, north of Iran has been completed. Gross alpha and beta activities were determined by direct measurement of water samples using α/β discrimination liquid scintillation counting (LSC) which provide simultaneous alpha and beta measurement. In this study, an Ultra-low background Wallac-Quantulus 1220 LSC system with α/β discrimination, the Optiphase Hisafe 3 cocktail and 20 ml Polyethylene vials were applied. The α/β discrimination parameter was optimized based on pulse shape analysis (PSA). The results show that the gross beta activity in all cases is lower than the maximum contaminant level (MCL) and the gross alpha activity is higher in some samples collected near Rasht City. Further investigations demonstrated that in cases with high gross alpha content the major contribution of the radioactivity content is due to uranium. Such measurements add useful information for the appropriate management of water supplies that are socially and economically very important to the health of residents living in the north of Iran.

Keywords: Gross alpha/beta; Liquid scintillation counting; Mineral water.

1. Introduction

Water is one of the important natural resources and because of its capacity to dissolve numerous substances, pure water rarely occurs in nature. Water pollutants result from many materials. Major water pollutants are chemical, physical or radioactive materials that degrade water quality. Determination of natural and artificial radionuclides in water is an important factor to estimate the risk of exposure, because of this; Gross alpha and beta activity are measured in water samples (USEPA; UNSCEAR, 2000).

Gross alpha activity is defined as the total activity of the alpha emitters once the radon has been eliminated. The gross beta activity is the activity of all beta emitters excluding ^3H , ^{14}C and other weak beta emitters. Measuring the gross α/β radioactivity is an indirect evaluation of committed dose in drinking water and checking compliance to derived limit values. World Health Organization proposed (WHO) limit values which are 0.1 Bq l^{-1} for gross alpha and 1 Bq l^{-1} for gross beta radioactivity. In order to perform more accurate measurements, single radionuclide contribution to alpha and beta activity is considered (Forte et al., 2002; Rusconi et al., 2004).

There are different methods for measuring the gross α/β activity in water as ISO 9696-9697, ASTM D 1890-1943 and EPA 900 (ISO 9696-9697, 1992; ASTM D1943-1890, 1996; EPA 900, 1980). In the present work, gross α/β activity in 27 springs water sample in north of Iran using LSC are studied.

2. Experimental

In LSC system with the α/β discrimination parameter based on pulse shape analysis (PSA), simultaneous alpha and beta measurement by one sample is possible (Forte et al., 2002). In other words, using a PSA system, separation of alpha and beta emissions was performed. In this way, the PSA should be set at optimum level and its Optimum value was found corresponding to minimum alpha and beta interference. Therefore, two standard samples were prepared by distilled water ($\text{PH} \approx 1.5$), and then traced with ^{241}Am as a pure alpha emitter and $^{90}\text{Sr}/^{90}\text{Y}$ as a pure beta emitter. Each sample was counted in different PSA levels, and measurements were repeated with increasing PSA value by 10 each time. The alpha interference was calculated by expression $T_\alpha = \frac{\beta}{\alpha + \beta}$ and beta interference by expression

$T_\beta = \frac{\alpha}{\alpha + \beta}$. The optimum PSA level was set in quantity when $T_\alpha + T_\beta$ is minimum (Forte et al., 2002; Villa et al., 2003). It was set for scintillator cocktail Optiphase Hisafe 3 in $\text{PSA} = 110$ as an optimum level (Table 1). Figure 1 shows the changes of real beta spectra with different PSA values for standard sample prepared with $^{90}\text{Sr}/^{90}\text{Y}$ tracer and Optiphase Hisafe 3 cocktail.

Table1. Alpha and Beta interference for ^{241}Am and $^{90}\text{Sr}/^{90}\text{Y}$ for different PSA

PSA level	T_α	T_β	$T_\alpha + T_\beta$
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70	0.013	0.346	0.360
80	0.014	0.223	0.238
90	0.018	0.147	0.166
100	0.022	0.029	0.052
110	0.026	0.012	0.039
120	0.041	0.002	0.044
130	0.068	0.002	0.070

To avoid losses radionuclides in sampling time, water samples were acidified to $\text{PH} \approx 2$ with HCL. For increasing sensitivity, water samples were pre-concentrated by slow evaporation on a hot plate to a tenfold volume reduction. In this case, the PH dropped to 1.5 and all the dissolved radon was desorbed (Forte et al., 2002; Rusconi et al., 2004). After cooling to room temperature, 12 ml of water was added to 8 ml of Optiphase Hisafe 3 cocktail in a 20 ml polyethylene vial. The prepared samples were counted in LSC system for 500 minutes.

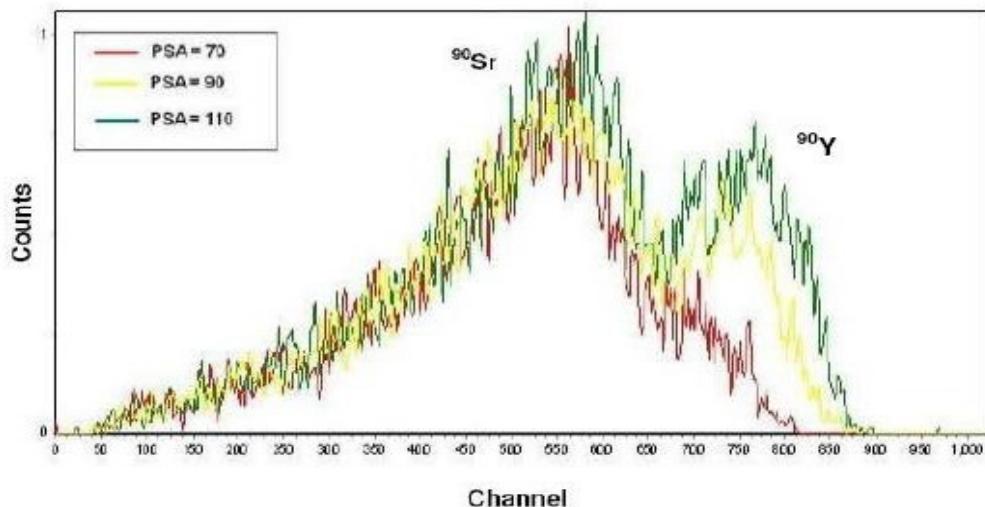


Fig 1. Changes of beta spectra with different PSA level for $^{90}\text{Sr}/^{90}\text{Y}$.

For calibration, a standard sample was prepared by 12 ml of distilled water. This sample was set in $\text{PH} \approx 1.5$ with HCL; then it was spiked with a known amount of ^{241}Am and $^{90}\text{Sr}/^{90}\text{Y}$ and 8 ml of Optiphase Hisafe 3 cocktail was added to it. For background determination, a sample was prepared by distilled water ($\text{PH} \approx 1.5$) similar to real samples. They were counted in LSC system for 500 minutes.

3. Results and discussion

A total of 27 spring water samples in the north of Iran were collected. The samples were acidified in situ and they were transferred to laboratory for analysis. The samples were counted by ultra low level liquid scintillation counting Wallac-Quantulus 1220. Some of the important parameters and the final results of samples analysis are presented in Table 2 and 3 respectively.

Figure 2 and 3 show the abundance charts of gross alpha and gross beta content of waters. The gross alpha and beta activity covers a wide range from 16 to 1051 mBq l⁻¹ and less than 22 to 630 mBq l⁻¹ respectively.

Table 2. Important parameter in results by LSC system

	Sample volume (ml)	Measur e time (min)	Measure window (channel)	Spectru m	Backgrou nd (cpm)	Efficienc y (%)	MDA (mBq l ⁻¹)
Gross α	80	500	470-900	α	0.12	98	5
Gross β	80	500	400-900	β	1.43	82	22

Table 3. Final results of analysis natural radionuclides concentration in the North of Iran springs

no.	Spring name	Latitude	Longitud e	Altitud e (m)	Gross α (mBq.l⁻¹)	Gross β (mBq.l⁻¹)
01	Ganzar	37° 18.582' N	49° 02.310' E	215	103± 15	122 ± 9
02	Shalma 1	37° 18.397' N	49° 02.034' E	250	74 ± 11	60 ± 6
03	Shalma 2	37° 18.397' N	49° 02.034' E	250	215± 29	84 ± 7
04	Masulekhani	37° 18.238' N	49° 00.108' E	575	61 ± 9	40 ± 5
05	Golpar	37° 00.462' N	49° 51.682' E	515	25 ± 4	23 ± 3
06	Arbinab	36° 56.464' N	49° 52.940' E	141	43 ± 6	35 ± 4
07	Larikhani	36° 55.654' N	49° 54.426' E	170	32 ± 5	63 ± 6
08	Kolah farangi	36° 54.239' N	49° 54.982' E	163	33 ± 5	27 ± 4
09	Siyah khuni	36° 54.735' N	49° 52.972' E	174	29.12 ± 4.59	56 ± 6
10	Nazem divan	36° 54.308' N	49° 54.707' E	160	26 ± 4	52 ± 5
11	Shur cheshme	36° 53.223' N	49° 54.430' E	143	110 ± 15	491 ± 24
12	Getebon	36° 49.569' N	49° 50.842' E	186	26 ± 4	< 22
13	Asiyab bar	36° 51.346' N	49° 49.891' E	163	79 ± 11	43 ± 5
14	Gol gol khani	36° 51.978' N	49° 50.528' E	151	72 ± 10	240 ± 14
15	Shahe shahidan	36° 51.842' N	49° 46.318' E	185	111 ± 16	60 ± 6
16	Sefid ab-	36°	50°	530	16 ± 3	< 22

	Garmabdasht	52.826' N 36°	13.829' E 50°			
17	Garmabdasht 1	52.131' N 36°	13.494' E 50°	460	49 ± 7	53 ± 6
18	Garmabdasht 2	52.099' N 36°	13.450' E 50°	460	54 ± 8	97 ± 8
19	Garmabdasht 3	52.093' N 36°	13.457' E 50°	455	54 ± 8	77 ± 7
20	Kakrude 1	48.568' N 36°	16.142' E 50°	131 0	35 ± 5	38 ± 5
21	Kakrude 2	48.519' N 36°	16.445' E 50°	128 0	25 ± 4	23 ± 3
22	Mayestan	46.544' N 36°	17.106' E 50°	101 0	1051 ± 138	630 ± 27
23	Asemanrud	46.560' N 36°	17.167' E 50°	101 5	38 ± 6	< 22
24	Haft emam- Rudbarak	49.415' N 36°	14.515' E 50°	665	41 ± 6	124 ± 9
25	Sajiran	52.950' N 36°	14.310' E 50°	670	20 ± 3	53 ± 6
26	Sefid ab	55.843' N 36°	15.586' E 50°	285	23 ± 4	< 22
27	Kiya khani	58.577' N 36°	18.440' E 50°	180	16 ± 3	< 22

The final results for gross alpha and beta activity show that only 5 samples have the gross alpha content upper than WHO proposed limit value and all of the samples have gross beta content lower than WHO limit value. Considering high alpha-content of some samples in the studied area, the geological studies have been performed. Further investigations demonstrated that in cases with high gross alpha content the major contribution to the radioactivity content is due to mineral containing uranium under the ground. Fortunately, these 5 mineral springs are not used as drinking water.

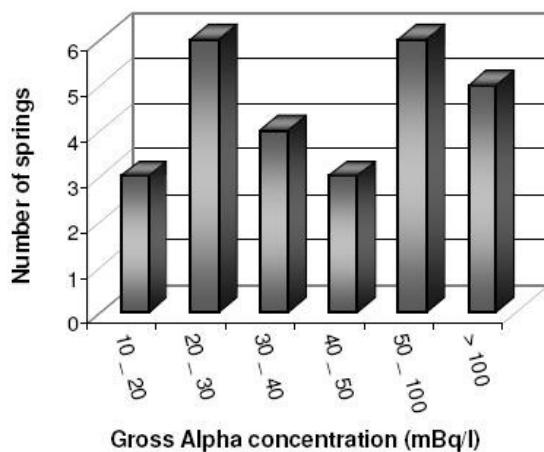


Fig 2. Distribution of Gross alpha concentration in 27 spring waters in the north of Iran.

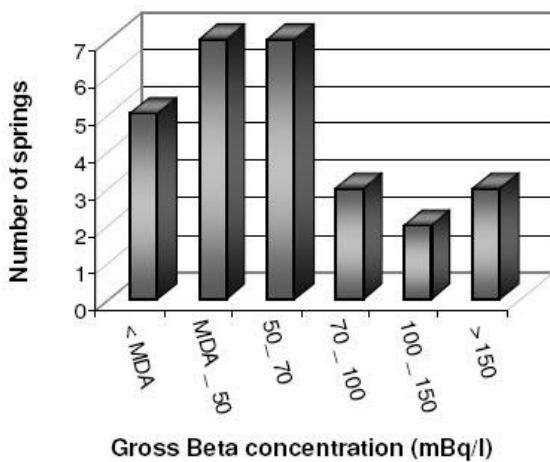


Fig 3. Distribution of Gross beta concentration in 27 spring waters in the north of Iran.

4. Conclusions

The liquid scintillation technique is very quick and simple procedure for analysis of the water samples. Reduced radiochemical and time-consuming procedures make this technique very suitable for environmental monitoring. This method should be developed for determination of the different radionuclides. The MDA ranges obtained for gross α/β are reasonable for environmental samples; but by increasing the counting time and the volume of sample, better sensitivity and lower MDA can be reached.

Because of simplicity, short time of counting and little volume of sample requirement, the study of other parts of region can be performed with this technique. This method can be routinely used in the analysis of a large number of samples. It is also necessary to consider the activity concentration of any radionuclide in drinking water for calculation the effective dose of population. It needs to a systematic radiometric monitoring program focusing on aquifer systems of region.

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